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BASE-AGE CONVERSION AND SITE-INDEX EQUATIONS FOR ENGELMANN SPRUCE STANDS IN THE CENTRAL AND SOUTHERN ROCKY MOUNTAINS

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ABSTRACT

Two mathematical models are presented. The first is used to convert 100-year base-age site index to 50-year base-age site index. The second describes 50-year base-age site index as an equation suitable for use with data processing by computer. Fifty-year base-age site-index curves and a base-age conversion curve are also presented.

KEYWORDS: site index, mathematical model,
Engelmann spruce, spruce-fir,
central and southern Rocky Mountains

A conventional tool for estimating productivity of forest land is site index (Alexander 1974). Site-index curves for Engelmann spruce *(Picea engelmannii* Parry), developed by Alexander (1967) for the central Rocky Mountains, are accepted as the standard throughout the central and southern Rocky Mountains. Jones (1974) says Alexander's curves give reasonable estimates of Engelmann spruce site index in the Southwest as well.

However, Alexander does not give a mathematical representation of his curves. For processing data by computer, it is desirable to be able to define the site-index relationship mathematically. Alexander presents the commonly used 100-year base-age site-index curves. Many users of site index prefer to use a 50-year base age; therefore, I converted the 100-year base age to a 50-year base age before developing the model for site index.

I developed the base-age and site-index models presented here by using a combination of Matchacurve techniques (Jensen 1964; Jensen and Homeyer 1970, 1971; Jensen 1973, 1976) and linear regression techniques (Draper and Smith 1966).

The purpose of this paper is to present base-age conversion and 50-year base-age site index as mathematical equations for processing large amounts of data by using computers.

BASE-AGE CONVERSION MODEL

Expected heights of Engelmann spruce trees in the dominant stand (Alexander 1967) at the 100-year breast-height age were fitted across site index using least-squares linear regression techniques to expected height at 50 years. The estimated height at 50 years is then the 50-year base-age site index. The equation for converting 100-year base-age site index to 50-year base-age site index for Engelmann spruce is:

$$S_{50} = \frac{S_{100} - 14.19432717}{1.276403138} \quad \text{or,} \quad S_{100} = 1.276403138(S_{50}) + 14.19432717$$

where

S_{100} = site index, 100-year base age (breast height)

S_{50} = site index, 50-year base age (breast height)

R^2 = 0.9998

The relationship between 50- and 100-year base age is shown in figure 1. The maximum deviation is 0.4444 site-index value (50-year base age) and the mean deviation is 0.2096 site-index value.

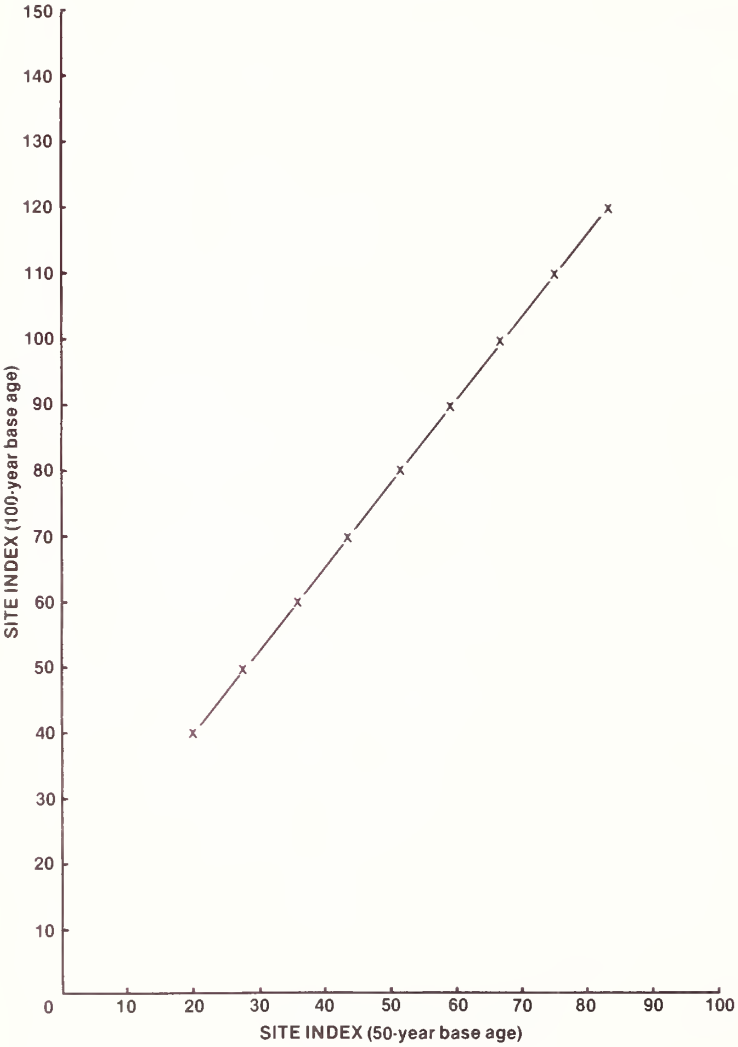

Figure 1.--Relationship of Engelmann spruce 100-year base-age site index to 50-year base-age site index for Central and Southern Rocky Mountains. Each data point is shown as an x.

SITE-INDEX MODEL

Alexander presents 100-year base-age (breast height) site-index curves for site indexes 40 through 120. Average total height and average breast-height age of the dominant stand are needed to determine site index from the curves. To build the model to change site-index base age, I used all data points from Alexander's expected height of Engelmann spruce trees in the dominant stand (Alexander 1967).

The first step in developing the site-index model was to fit 50-year base-age site index to expected height for each age class using least-squares linear regression techniques. For each age class, site index was found to be a linear function of expected height.

The second step was to use Matchacurve techniques to determine appropriate transformations of breast-height age for the y-axis intercepts and slopes of the linear function found in the first step. It was found that the best transformations of breast-height age for both the y-axis intercept and the slope changed at 50 years of age breast height; therefore, a segmented model was fitted.

The third step was to fit the y-axis intercepts and the slopes to the breast-height age transformations. A check of this preliminary model showed the model did not pass exactly through the known heights at 100 years; so a correction factor was developed. Application of the correction factor increases the variation around the function slightly.

The site index model that I developed from Alexander's curves is:

$$S = a + bH$$

where

S = site index, base age 50 years (breast height)

H = average total height of 6 or more dominants:

20 to 50 years of age breast height:

$$a = 7.321450260 - 0.087970990\ (A - 20.0)^{1.3}$$

$$b = 2.236555891 - 0.430830223\ (A - 20.0)^{0.31}$$

51 to 300 years of age breast height:

$$a = -25.40943950 + 1.477047639\text{E-}05\ (300.0 - A)^{2.6}$$

$$b = 0.712121213 + 7.457608936\text{E-}17\ (300.0 - A)^{6.5}$$

A = average breast-height age of dominants in stand

$R^2 = 0.9906$

Fifty-year base-age site-index curves for Engelmann spruce are shown in figure 2. Table 1 presents 50-year base-age site index for specific dominant stand heights and stand ages.

I checked this model by comparing predicted heights with Alexander's estimated heights. Since the largest deviation is 2 feet in estimated height and the mean deviation is 0.4789 foot, this model is considered to be adequate. The model will not function below 20 years or over 300 years.

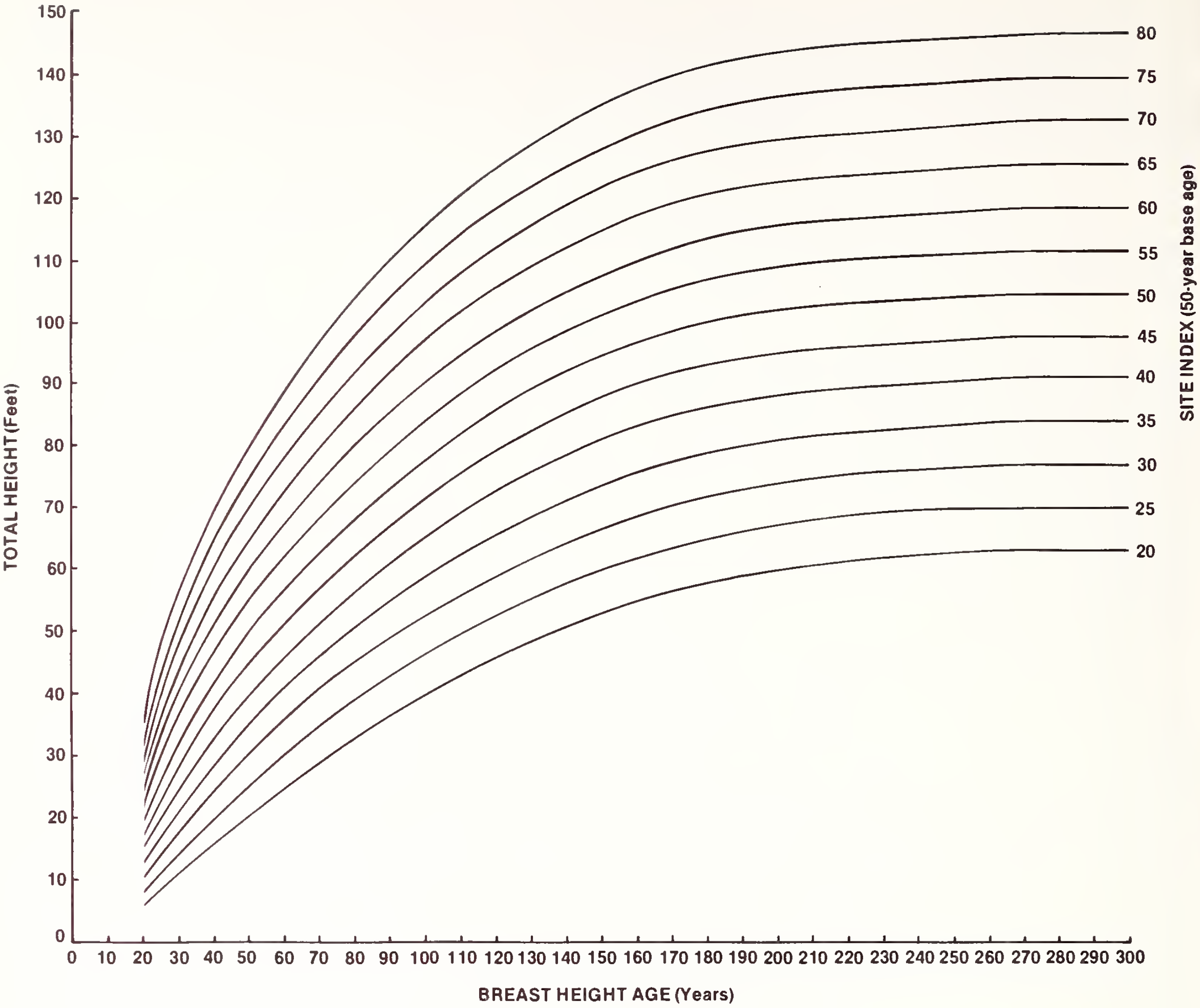

Figure 2.--Site-index curves for Engelmann spruce in the Central and Southern Rocky Mountains.

Table 1.--*Expected site index (50-year base age) for Engelmann spruce stands in the Central and Southern Rocky Mountains*

Stand age[1]	Height of dominant stand in feet														
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
20	30	[2] 52	74	97	119	--	--	--	--	--	--	--	--	--	--
30	19	33	46	60	73	87	101	114	--	--	--	--	--	--	--
40	14	26	37	49	60	72	83	95	106	118	--	--	--	--	--
50	10	20	30	40	50	60	70	80	90	100	110	120	--	--	--
60	7	16	25	35	44	53	63	72	81	91	100	109	119	--	--
70	4	13	21	30	39	48	57	65	74	83	92	101	109	118	--
80	1	10	18	26	35	43	51	60	68	77	85	93	102	110	118
90	0	7	15	23	31	39	47	55	63	71	79	87	95	103	111
100	--	4	12	20	28	36	43	51	59	67	75	82	90	98	106
110	--	2	10	17	25	33	40	48	55	63	71	78	86	93	101
120	--	0	8	15	23	30	38	45	53	60	67	75	82	90	97
130	--	--	6	13	21	28	35	43	50	57	65	72	80	87	94
140	--	--	4	12	19	26	33	41	48	55	63	70	77	84	92
150	--	--	3	10	17	25	32	39	46	54	61	68	75	82	90
160	--	--	2	9	16	23	31	38	45	52	59	66	74	81	88
170	--	--	1	8	15	22	29	37	44	51	58	65	72	79	87
180	--	--	0	7	14	21	28	36	43	50	57	64	71	78	86
190	--	--	--	6	13	20	28	35	42	49	56	63	70	77	85
200	--	--	--	5	13	20	27	34	41	48	55	62	70	77	84
210	--	--	--	5	12	19	26	33	40	48	55	62	69	76	83
220	--	--	--	4	12	19	26	33	40	47	54	61	68	76	83
230	--	--	--	4	11	18	25	32	40	47	54	61	68	75	82
240	--	--	--	4	11	18	25	32	39	46	54	61	68	75	82
250	--	--	--	3	11	18	25	32	39	46	53	60	68	75	82
260	--	--	--	3	10	18	25	32	39	46	53	60	67	75	82
270	--	--	--	3	10	17	25	32	39	46	53	60	67	74	82
280	--	--	--	3	10	17	24	32	39	46	53	60	67	74	81
290	--	--	--	3	10	17	24	32	39	46	53	60	67	74	81
300	--	--	--	3	10	17	24	32	39	46	53	60	67	74	81

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[1] Average breast-height age of dominants in stand.

[2] The blocked-in area represents the extent of Alexander's Engelmann spruce site-index curves. Values outside the blocked-in area are extrapolated from the curve form and therefore should be used with extreme caution.

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